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PUBLICATION 667
FARMERS' BULLETIN 85

ISSUED OCTOBER, 1950
REVISION

CANADA DEPARTMENT OF AGRICULTURE

DISEASES OF TOBACCO IN CANADA

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Published by authority of the Right Hon. JAMES G. GARDINER, Minister of Agriculture
Ottawa, Canada

8M—14218—10:50

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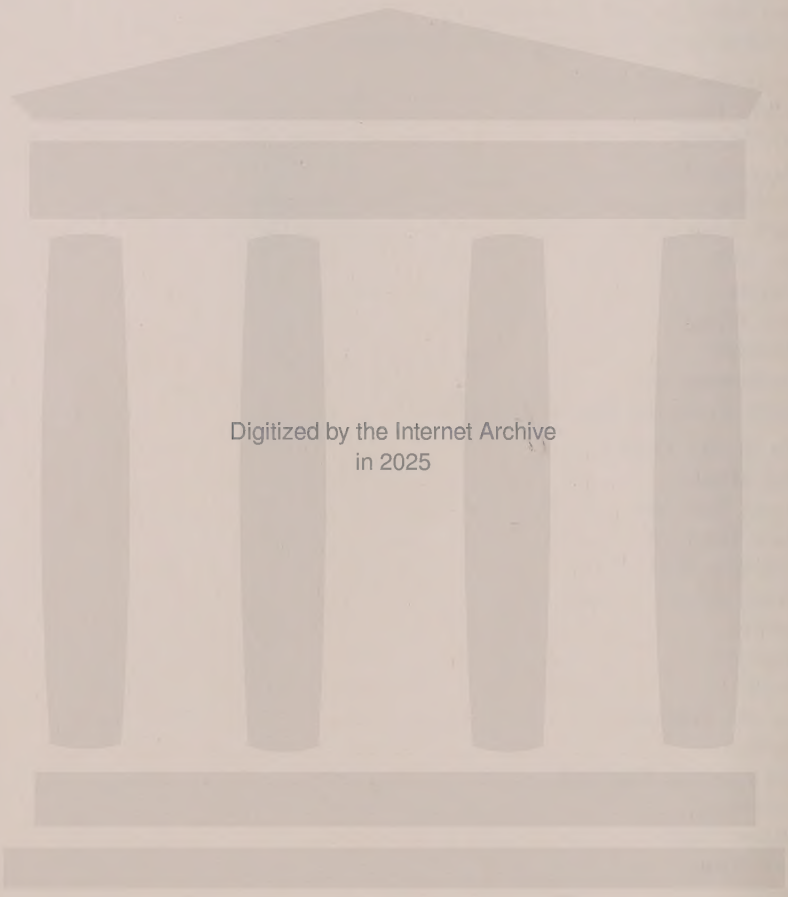

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DISEASES OF TOBACCO IN CANADA

L. W. Koch and G. H. Berkeley

INTRODUCTION

The commercial production of tobacco in Canada began in Quebec along the banks of the St. Lawrence River. Although the use of tobacco by the natives was general even in French colonial days, it was not until about 1835 that the Government encouraged its production. Records indicate that soon after Ontario was settled tobacco was produced along the shore of Lake Erie and shipped south to New Orleans. From that time up to the present, production of tobacco in Ontario has expanded steadily, the greatest expansion having occurred during the past 25 years. In 1949 the Ontario acreage consisted of approximately 87,000 acres of flue-cured, 12,000 acres of burley and 1,500 acres of dark type. In Quebec approximately 5,000 acres of flue-cured, 3,500 acres of cigar and 2,000 acres of pipe tobacco were grown in the same year. The actual value of the tobacco crop to producers in Canada has increased remarkably during the past few decades. In 1924, for instance, the total value was approximately $3,000,000 while the 1949 total value amounted to approximately $55,000,000.

In Ontario, the areas of greatest production are in the New Belt which comprises Norfolk, Elgin, Oxford, Middlesex, and Brant counties in the Lake Erie region and, to a lesser extent Simcoe, Ontario, Durham, and Peterborough counties of the Georgian Bay and Lake Ontario districts. These areas are devoted entirely to tobacco of the flue-cured type. The Old Tobacco Belt of Ontario, consisting of Essex and Kent counties, produces all of the burley and dark type tobacco and a very limited amount of flue-cured type. In Quebec, on the other hand, cigar, pipe, and flue-cured types are all grown in the so-called northern belt north of Montreal in the counties of L'Assomption, Montcalm, Berthier and Joliette, while in the area south of Montreal along the valley of the Yamaska River some of the finest quality cigar binder type is grown.

The Seed-bed and its Relation to Tobacco Disease Control

Only recently has the importance of disease prevention in the seed-beds been fully appreciated by tobacco growers in Canada. Because of this fact, the growers of flue-cured tobacco, who comprise the majority of Canadian tobacco growers, and are relatively new to the business, have uniformly adopted the practice of steaming their seed-bed soil. On the other hand, because the growing of burley, cigar-leaf, pipe, and dark type tobacco has evolved slowly over a long period, various methods of seedling production have been used and many of these methods have been developed and maintained for reasons other than disease control. In consequence, certain practices, such as the addition of unsteamed muck to last year's seed-bed as is practised by numerous burley growers in Kent county, Ontario, are less efficient for disease control than are the standard practices in the production of the flue-cured type.

Sanitation

1. The seed-bed should not be located near the curing barn or warehouse.

2. Boards and cloth covers that are to be used a second time should be disinfected. This may be accomplished in the case of the former by direct exposure to steam for a short period, or by spraying with 3 per cent formaldehyde

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and then covering with wet bags or papers for about 48 hours. Cloth covers should be boiled in water for 10 minutes. Tools used in working the seed-bed should not be stored in any building where tobacco is stored or handled.

3. Tobacco trash, manure, and manure water should not be used in the seed-bed, but if for some reason they are used, they should be added to the soil before it is sterilized.

4. Special care should be taken to see that the refuse from the previous year's crop does not come in contact in any way with the seed-bed.

5. Tobacco stalks should not be used for insulation or for drainage purposes under the seed-bed, because, if so used, they may infect the seed-bed with mosaic, or certain fungus and bacterial diseases.

6. Neither tobacco smoking nor chewing should be permitted while working in the seed-bed.

7. Before work is begun in the seed-bed, the hands should be thoroughly washed with soap, under running water preferably.

8. Weed control in the immediate vicinity of the seed-beds should be practised.

Sterilization of Soil

Regardless of the method of seedling production in Canada, sterilization of the seed-bed soil is essential both for disease and weed control. This may be most effectively accomplished by means of steam. In the absence of equipment for steaming the soil a satisfactory job of partial sterilization may be carried out by using formaldehyde, methyl bromide, urea, or certain other chemicals.

If sterilization is effected by steam, not only are the disease-producing organisms killed, but in addition, weed seeds are destroyed, and plant nutrients in the soil are rendered more available to the seedlings. If steam is used, it is especially important to spade the soil previous to steaming, and to have the soil moist—not too wet nor yet too dry—since satisfactory penetration by the steam is not possible if the soil is compact, dry, wet, or frozen. When the soil is in a satisfactory condition, that is, loose, and just moist enough to hold its shape when squeezed tightly in the hand, excellent results may be obtained by steaming for 30 minutes, provided that the pressure at the boiler is between 90 and 100 pounds. It is preferable that seed should not be sown until at least 10 days after sterilization, since freshly-steamed soil often has a temporary detrimental effect on the growth of seedlings.

If disinfection is effected by means of the chemicals available for such purpose, destruction of disease-producing organisms and weed seeds is often less complete than with the use of steam. However, rapid improvements are being made both in chemicals and methods for their use in seed-bed soils.

When formalin is used, the soil should be loose and comparatively dry, so that it may be able to soak up the formalin solution. Formalin solution made up of 1 gallon of commercial formalin to 50 gallons water should be applied at the rate of $\frac{1}{2}$ to 1 gallon per square foot of soil. Then papers or gunny sacks soaked in formalin solution should be placed over the soil for at least 48 hours in order to retain the active formaldehyde fumes. After 48 hours the bags should be removed and the soil should be turned over or aerated at intervals until the odour of formaldehyde is extremely faint or lacking. This may require as long as 10 days. If proprietary chemicals are used for disinfecting the seed-bed soil, the directions of the manufacturer should be closely followed.

Sterilization either by steam or chemicals may be done late in the fall or early in the spring. Fall sterilization has some advantages, though obviously there is the chance of contamination by weed seeds or disease-producing organ-

isms before spring. Sterilization in the fall is more convenient from the standpoint of time and labour, and often permits earlier seeding, due to the fact that in the spring unfavourable weather conditions sometimes necessitate delay in sterilization.

Fertilization

Observations of tobacco seedlings growing under various conditions in the different tobacco-growing areas have indicated that serious injury frequently results from excessive fertilization in the seed-beds. Local recommendations should be strictly adhered to. Provided that a suitable muck is used, no more than 1 bag of commercial tobacco fertilizer per 1000 sq. ft. of seed-bed should be applied. The fertilizer should be well worked into the seed-bed soil before seeding.

Seed Selection and Treatment

Seed should be selected from healthy plants only. Although disinfection of seed is not generally practised in Ontario or Quebec, it is recommended in the case of seed of unknown or doubtful origin. This is particularly true if the seed has been obtained from districts where seed-borne bacterial leaf spot diseases are serious. The safest material to use is silver nitrate 1:1,000 i.e., 1 part of silver nitrate (14 gm.) to 1,000 parts of water (1 qt.). Place the seed in a cloth bag and immerse in silver nitrate solution for 15 minutes, then spread out to dry. The seed is ready for use when dry.

Ventilating and Watering of the Seed-bed

In the production of tobacco seedlings, temperature and moisture conditions are most important. Too high or too low a temperature and too humid an atmosphere may not only adversely affect germination of the seed but, at the same time, may favour certain diseases. Therefore, it is essential to maintain suitable temperatures for germination and to avoid an atmosphere that is too humid or a soil that remains wet for too long a period. For these reasons the temperature should be maintained between 80 and 88° F., since tobacco seed germinates best at these temperatures, and humidity should be controlled by adequate ventilation and care in watering. During the short but critical period of germination, seed-beds should be kept moist with frequent light sprinklings, rather than with fewer but heavier applications. Watering should be done around mid-day in order that the humidity may be greatly reduced before night. These practices will reduce to a minimum damage from damping-off and other seed-bed diseases.

DISEASES IN THE SEED-BED

Yellow Patch

One of the more important seedling diseases of tobacco in Ontario is known as yellow patch, because it occurs as patches of yellowed plants in the seed-bed. In certain years it becomes the most serious seedling disease of tobacco.

Symptoms

Primary symptoms of yellow patch may appear at any stage of seedling growth though they usually become evident several weeks after the seedlings appear above ground. Above-ground symptoms consist of chlorosis, usually pronounced, and stunting of affected seedlings in patches of irregular shape

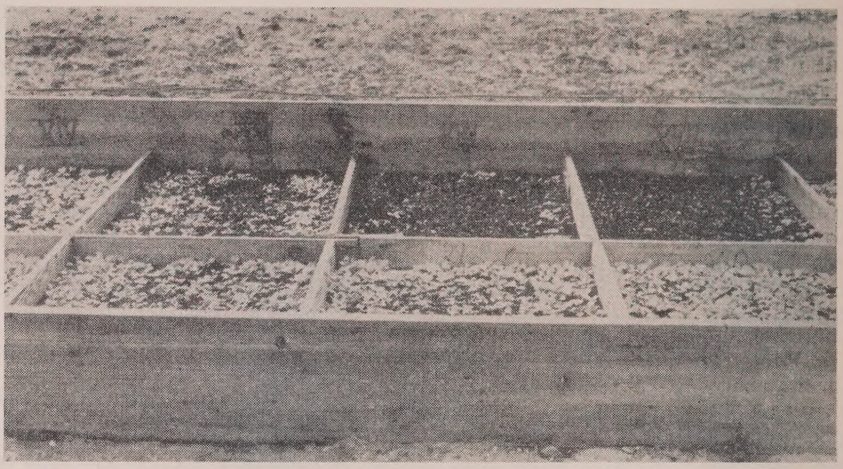

FIG. 1.—Upper row: Yellow patch of tobacco seedlings induced by fertilizer high in organic nitrogen. Lower row: Tobacco seedlings which received normal fertilizer application.

(Fig. 1). Roots of affected seedlings exhibit various degrees of discoloration and rotting. In severe cases, affected seedlings die, whereas in milder cases, new rootlets develop above the rotted ones and, though they, too, may continue to rot for some time, recovery frequently sets in just prior to the transplanting period and growth may afterwards be normal.

Cause

Intensive investigations of this trouble in Ontario have proved that it is caused by excessive fertilization, a condition that may be brought about by the application of sheep manure to the seed-bed—a practice much too common among tobacco growers—or by the addition of excessive amounts of fertilizer, particularly those containing more than 2 per cent nitrogen. Experimental evidence has indicated that the organic rather than the inorganic nitrogen fraction of the fertilizer is usually responsible for the trouble.

Control

Muck should be carefully analysed before it is used for seed-bed purposes. Care should be taken not to use more than the recommended application of fertilizer.

If yellow patch develops in the seed-bed, allow the soil to dry out thoroughly for several days or longer, after which it may be well watered. This practice often hastens recovery.

Blue Mould

In its gradual advance northwards since 1922, from the Florida tobacco-growing districts, blue mould reached the Old Belt of the Ontario tobacco-growing district in 1938. Following mild outbreaks here and there in this area and also in the New Belt during the subsequent few years it suddenly assumed epidemic proportions in 1945. Each year since that time blue mould has been the most important seeding disease with which Ontario tobacco growers have had to contend. To date the disease has not made its appearance in the Quebec tobacco-growing areas.

Symptoms

The greatest damage caused by this disease is to seedlings approaching the transplanting stage, although both very young seedlings and plants in the field may become infected. Blue mould may be first detected by the downward cupping of the tips of affected leaves and the presence of irregularly shaped yellow blotches (Fig. 2) on the upper surface of the leaves. However, the most characteristic symptom is the presence of a dense, greyish-blue "down" or mould on the under surface of affected leaves, giving rise to the common name, blue mould (Fig. 3). Under moist conditions entire leaves soon become involved and appear as though scalded, and give off an offensive odour of decay. On the other hand, if the weather is dry and warm, affected portions dry out and become brown and shrivelled with little or no "down" appearing on the lower surface. However, with a return to cool, moist conditions, the disease progresses and "down" develops on affected portions. Frequently the disease develops in patches in the seed-bed, which can be recognized by their yellowish appearance and a pronounced tendency to wilt. In cases of severe attack, the plants ultimately collapse and die. Temporary recovery often occurs but may be followed by secondary outbreaks during cool, wet weather.

Cause

Blue mould is caused by the fungus, *Peronospora tabacina.*

Conditions which Favour the Disease

High humidity and low temperature, a combination which often occurs during May and early June in Ontario tobacco-growing districts, is favourable for the development of blue mould. In general, it may be stated that the fungus is most active at and below temperatures of 60° F., and becomes inactive at temperatures higher than 85° F.

FIG. 2.—Blue mould on tobacco. Common symptoms where infection has been arrested.

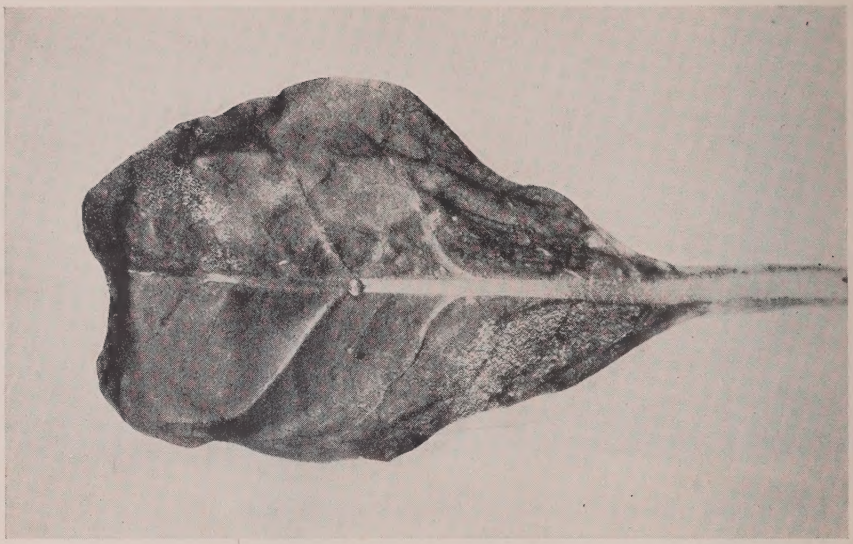

FIG. 3.—Blue mould on tobacco. Note the downy growth on underside of leaf.

Control

The choice of a method to control this disease depends largely on seed-bed construction and available equipment. For tobacco growers in Essex and Kent counties the following control measures are recommended:

GAS TREATMENT—Paradichlorobenzene crystals (PDB)

(*a*) *Cotton-covered seed-beds*

The PDB treatment is recommended primarily for this type of seed-bed beginning as soon as the disease makes its first appearance.

1. Scatter the fine PDB crystals over the ordinary, thin cotton cover in the early evening at the rate of 3 lb. per 100 sq. yd. Two pounds for the same area is sufficient in warm weather.
2. To hold the gas in the seed-bed, cover the crystals and cotton with a heavier grade of cotton (60 threads per inch). This second cover should be larger than the beds so that the sides may be fastened. One cover may serve for two beds if they are close enough.
3. Remove the covers between 8 and 10 o'clock in the morning.
4. Treat the bed for three consecutive nights and twice a week afterwards.

Six to eight treatments will be sufficient even during the worst season.

(*b*) *Glass-covered Flatbeds*

The PDB treatment should be effective also in glass-covered, flat beds provided the sashes fit tightly and are removed in the morning before temperatures rise to the point where injury will result.

The PDB in the latter type of seed-bed should be placed on a narrow shelf about 2″ wide supported on the inside of the walls a short distance (at least 3 inches) below the sash.

SPRAY TREATMENT

This method of control is recommended for the NEW TOBACCO BELT and also for the A-BEDS, GREENHOUSES and CERTAIN GLASS-COVERED FLATBEDS of

Essex and Kent counties, where it is not feasible to use PDB or where the grower has a preference for spraying. To be effective, spraying should be started in advance of the appearance of the disease.

Use a ferric carbamate according to the manufacturer's directions.

In preparing the spray solution first make a paste by adding a small amount of water to the material and then dilute to the required amount. These materials will wet more easily when a wetting agent is added but addition of the latter is not essential.

Spray applications should be started when leaves are about the size of a dime and repeated twice weekly until transplanting time. Six or more applications may be necessary for satisfactory control. On the average 4-5 gal. spray are required per 100 sq. yd. of seed-bed when the plants approach the transplanting stage.

In spraying tobacco seedlings for the prevention of blue mould, it should be remembered that the use of any of the materials recommended will also assist very considerably in the control of damping-off regardless of the occurrence of blue mould.

DUSTING

For those who prefer dusting to spraying, prepared ferric carbamate dust mixtures may be applied about twice weekly with a hand duster or power duster. Dusting, of course, can be carried out much more quickly than spraying though single applications are not so lasting. Approximately 2-4 lb. dust mixture per 900 sq. ft. per application are required, depending on the size of the plants.

ADDITIONAL REQUIREMENTS

In view of evidence that the blue mould fungus may overwinter in the unsteamed seed-bed soils of Kent county, it would be wise for tobacco growers in that county who have experienced outbreaks of this disease (1) to prepare their tobacco seed-beds on a new location and also (2) to disinfect the used sideboards with a 1-25 formalin solution (4%) using a broom or sprayer for the purpose.

As soon as feasible after the initial appearance of the disease in their seed-beds, growers with glass-covered flatbeds, A-beds or greenhouses should close the ventilators and allow the inside temperature to rise to 105°-110° F. for a period of approximately five hours per week. Such a practice which, of course, can only be carried out in the presence of sunshine, usually reduces the severity of the disease. However, the capacity of tobacco seedlings to withstand high temperature treatment varies considerably according to their succulence. It has been proved that temperatures above 110° F. will severely injure *tender* tobacco seedlings. No damage should result, however, at the recommended temperatures, provided that the seedlings are normally tough and that reasonable care is exercised. It has also been demonstrated that *a high humidity in the greenhouses at the time the temperature is raised, reduces the effectiveness of the treatment.*

In the event of blue mould infection, recovery of seedlings may be speeded up by the application of nitrate of soda or ammonium nitrate.

Damping-off

Damping-off usually occurs in small localized areas of the seed-bed. Affected plants which are commonly attacked near the groundline wilt and ultimately die. In a moist atmosphere a wet rot may develop, sometimes

accompanied by a white mould on the rotted plants. In a drier atmosphere affected seedlings may dry up and show no signs of mould. In some cases young seedlings are killed before they emerge.

Cause

Damping-off may be caused by several fungi commonly present in soils, but they may be destroyed by steam sterilization.

Conditions which Favour the Disease

A humid asmosphere, wet seed-bed soil and thick stands of seedlings all favour damping-off. Where one or more of these conditions prevail, the disease may destroy entire seed-beds in a relatively short time.

Control

1. Use sterilized soil in the seed-bed. 2. Ventilate beds as much as possible. 3. Avoid heavy and too-frequent watering. 4. Aim to have the surface of the seed-bed as dry as possible by evening. 5. Avoid too thick a stand of seedlings. Seeding at the rate of 1 ounce of seed for 1,200-1,600 square feet is recommended, depending, of course, upon the germination test of the seed. 6. At the first sign of damping-off after the true leaf stage, spray or dust with a ferric carbamate according to the manufacturer's directions. 7. If severe damping-off appears in the seed-bed, dig out the diseased patches and disinfect the areas from which plants were taken with 1-25 formalin solution (4%). Also reduce watering to a minimum and increase ventilation, keeping in mind, however, that tobacco seedlings do not stand chilling.

FIG. 4.—Blackleg on tobacco seedlings. Note blackened stem near ground line.

Symptoms

Blackleg

This is a bacterial disease that may, at times, cause considerable loss in the seed-bed, particularly if the stand of seedlings is too thick, and humid conditions prevail.

The conspicuous symptom of blackleg, as the name implies, is a black rot either along one side or completely girdling the stem from the ground-line upwards (Fig. 4). As a rule the disease is localized in distribution, and seldom makes its appearance until the seedlings are almost large enough to be transplanted.

Control

So far as is known, the practices recommended for the control of damping-off should give satisfactory control of blackleg.

Black Root-rot

Black root-rot is occasionally a serious disease of tobacco seedlings in those parts of Ontario and Quebec where steaming of the seed-bed soil is not generally practised. On the other hand, where steaming is carried out regularly, this disease occurs only in parts of the seed-bed where steaming was either overlooked or inadequate.

Symptoms

Infection of seedlings by this disease can be recognized by the decay and black discoloration of rootlets, accompanied by stunting and usually chlorosis of the above-ground parts. Even quite small seedlings may be attacked. Seed-beds affected with black root-rot are always "patchy" in appearance because of the lack of uniformity in size of plants and some yellowing may also be apparent where seedlings are of the burley type.

Cause

Black root-rot is caused by the fungus *Thielaviopsis basicola.*

Conditions which Favour the Disease

The disease is distinctly favoured by low temperatures, high alkalinity and abundant soil moisture.

Control

Black root-rot may be prevented in the seed-bed by sterilization of the seed-bed soil with steam or by disinfection with formalin. It should also be pointed out that in those tobacco-growing areas of Canada where tobacco seedlings are grown under glass, damage from the disease may readily be kept to a minimum by maintaining high temperatures and low soil moisture in affected seed-beds. However, when it becomes known that black root-rot is present in a seed-bed great care should be taken to select only healthy seedlings for transplanting to the field.

Sore Shin

This disease annually causes some damage to tobacco in the seedling stage in both Ontario and Quebec but probably more severe damage is incurred in the field. In certain years some plants in fields of flue-cured tobacco in the Old Tobacco Belt of Ontario are often lost soon after transplanting due to attack by the organism causing this disease.

Symptoms

Affected plants show brown or black discoloured areas on the stem near the ground level. The extent of the lesion varies, sometimes being limited to one side or, in severe cases, completely girdling the stem. In mild cases, only superficial tissues are involved, while in severe attacks both cortical and vascular tissues are invaded. In the latter, affected plants "damp-off" if in the seedling stage and become so weakened or stunted in more mature stages that they frequently have one or more dead leaves at the top of the plant and they either break off completely or bend over without recovery after a windstorm.

Cause

Sore shin is caused by a soil-inhabiting fungus *Rhizoctonia Solani.* It is present in most cultivated soils of Canada.

Control

Seedlings should be examined very carefully at the transplanting stage to make sure that plants showing superficial brown lesions characteristic of mild infection are not transplanted to the field. Even though steaming of the seed-bed soil kills this fungus, seed-beds may become reinfested in case of excessive soil moisture or thick stands of seedlings. Therefore, adequate ventilation, proper rate of seeding, and care in watering will reduce the disease to a minimum.

Since losses in the field in Ontario have been greatest where drainage is poorest and where exceptionally heavy crops of rye have been ploughed under just prior to the tobacco crop, with only partial decomposition in the meantime, consideration should be given these factors.

Moulds

Various fungi, commonly referred to as moulds, make their appearance in tobacco seed-beds and occasionally cause considerable damage. In most cases they do not directly attack the plants but they often interfere seriously with normal plant development by uprooting the seedlings, by producing incrustations of spores or fungous material on the leaves and stems (Fig. 5a), thus leading to suffocation of the plants, or by the production or secretion of materials injurious to the plants and often resulting in stunted growth and chlorotic appearance.

A common offender is *pink mould* caused by *Pyronema* spp. This mou'd usually appears several weeks, or sooner, after steaming of the seed-bed soil. It seldom causes damage because it usually disappears by the time or soon after the seedlings emerge. Occasionally, however, it continues to flourish in the more shaded and more poorly-drained portions of the seed-bed, and under such circumstances either interferes with emergence of some seedlings or chokes them out soon afterwards.

Another "mould" frequently observed by growers, is the so-called *green mould.* This is actually caused by blue-green algae which are quite distinct from fungi. They occur most frequently in seed-beds where drainage is imperfect and moisture too abundant.

Still another group of moulds causing trouble in tobacco seed-beds in Canada are the slime moulds. These are fungus-like organisms which during cloudy, damp weather often rapidly envelop entire plants or groups of plants with a slimy incrustation varying in colour, but often grey or yellow.

All of the above-mentioned moulds tend to disappear rapidly under direct sunlight and as a result of adequate ventilation and drying-out of the surface of affected beds. The application of fixed copper or ferric carbamate sprays also tends to discourage their development.

Fig. 5a.—Tobacco seedling attacked by slime mould fungus.

Grey Mould

Grey mould is a disease which may be observed on seedlings in Ontario at any stage but more often occurs on plants approaching the transplanting stage.

Symptoms

The disease usually appears first on the oldest leaves. Under dry conditions affected parts of leaves turn brown and occasionally have a yellowish border. Under more humid conditions a wet rot develops and under such conditions leaf petioles and even main stems are sometimes involved. This may or may not result in death of the plants. Stem lesions are dark brown to black and sunken.

Cause

Grey mould is caused by the fungus *Botrytis cinerea.*

Conditions which Favour the Disease

Grey mould is favoured by excessive watering and high relative humidity. Where seedlings are crowded or weakened by shading, the disease appears to be more severe.

Control

This disease may be kept under control by the same means as damping-off. Avoid excessive watering and thick stands of seedlings. Ventilate as much as possible to maintain low relative humidity.

Chlorosis

Every year in southwestern Ontario, usually during May, an abnormal condition of tobacco has been observed which is characterized by a pronounced chlorosis or yellowing of the tissues between the veins of the young leaves. This condition only appears when the plants are at the 4- to 6-leaf stage and when

severe, it can readily be identified at some distance. Usually the yellowing is most pronounced on, and sometimes limited to, the two centre leaves. In other cases only the edges of the outer leaves become yellow. Occasionally the affected leaves become somewhat narrowed and elongated. It is characteristic for this condition to appear suddenly throughout part or all the seed-bed, and it often disappears quite as suddenly. Roots of seedlings affected in this way are quite normal. The cause of this condition has been attributed to the chilling of the seedlings due to sudden and extreme drops in night temperature.

Mushrooms, etc.

Different fungi which thrive on decaying organic matter may cause some damage in seed-beds. In Kent county, Ontario and in Quebec, where steaming of seed-beds is not generally practised, considerable damage occurs in some seasons, as a result of the growth of fleshy fungi, or "mushrooms" in the seed-bed. These fungi cause damage indirectly, either by heaving of the soil, thus causing the soil to dry and the seedlings to wither, or by killing the seedlings as a result of the decay of the mushrooms.

Conditions which Favour this Trouble

Insufficiently decomposed manure or decaying wood and leaves under the beds, along with poor drainage, shading of the beds and inadequate ventilation, are common causes of mushroom growth.

Control Measures

Where sterilization of seed-bed soil is practised trouble from these fungi is not usually experienced. If manure or other organic matter is used, it should be thoroughly rotted, and if these fungi appear in seed-beds, remove them carefully and ventilate as well as possible.

FIG. 5b.—Tobacco seedling showing 2,4-D injury.

Injury From the Use of Herbicides

With the widespread use of herbcides of the 2,4-D type on lawns and around greenhouses on farm properties, quite frequently the same sprayer is used both for killing weeds and for spraying tobacco seedlings. It also happens occasionally that such chemicals are applied to areas immediately adjacent to tobacco seed-beds. In either case there is a strong possibility that tobacco seedlings may be injured.

During the past several years a considerable number of cases of 2,4-D injury on tobacco were observed or reported, particularly throughout Kent county where intensive weed spraying was carried on. In that area many of the seed-beds are flat, outside, cotton-covered beds, and are thus exposed to drift from adjacent weed-spraying operations.

Symptoms

Seedlings injured by chemicals such as 2,4-D exhibit extreme leaf distortion. Affected leaves droop, are narrow and often more or less strap-shaped with very prominent veins, wavy or deeply toothed leaf margins (Fig. 5b), and in some cases the surface is blistered. In most instances, the malformation is confined to certain sets of leaves. Symptoms may be confused with those of virus infection, but if plants are examined some time after injury by the chemical the youngest leaves will be normal in appearance.

Quite often seedlings injured by 2,4-D or a similar weed chemical, have only mild leaf symptoms, which tend to disappear, but show characteristic and severe root symptoms long afterwards in the field. Root symptoms consist of clusters of closely-spaced and thickened abortive rootlets. Such rootlets fail to develop normally, often remaining clustered and shortened until late in the season.

DISEASES IN THE FIELD

Blue Mould

In certain years blue mould causes considerable damage in Ontario fields as well as in seed-beds. Infection may either be carried to the fields on the transplanted seedlings or it may result from spore showers after healthy plants are transplanted to the field.

Fig. 6.—Blue mould on tobacco leaf approaching maturity in the field.

Symptoms

Field symptoms of blue mould consist of spots on the leaves varying in size but usually large ($\frac{1}{2}$ to $\frac{3}{4}$ inch) and more or less circular. Depending on weather conditions subsequent to infection, tissues in the affected spots may be dead and of uniform brown colour (Fig. 6) or they may be distinctly yellow in which case the progress of the fungus has been arrested. Often numerous spots occur on a single leaf and though lower leaves are more commonly affected than those on upper portions, sometimes all leaves are affected. If infection and advance of the fungus remains uninterrupted until spots become brown, the tissues ultimately drop out and the leaf then assumes a ragged appearance.

Control

Affected seedlings in seed-beds adjacent to tobacco fields should be destroyed as soon as possible after transplanting operations are completed. It is also advisable to refrain from going into affected plantations so long as free moisture is present on the plants.

Brown Root-rot

During the past decade brown root-rot has become of increasing importance in Canada, more particularly to burley tobacco growers in the Old Tobacco Belt of southern Ontario. It also occurs annually, to a lesser extent, throughout all other tobacco-growing areas of Ontario and Quebec.

Symptoms

As the name implies, the disease is characterized by a browning and rotting of the root system. When affected plants are removed from the ground the outer regions of affected roots are frequently sloughed off leaving only the central thread-like core extending beyond the normal root portions. As the season progresses, root systems of severely affected plants frequently develop a bunchy appearance due to the destruction of many roots and the excessive development of new ones. Gross symptoms of brown root-rot for the most part resemble those of black root-rot except in colour. Aboveground symptoms are in the main similar to those of black root-rot consisting of stunting, yellowing of the leaves, and premature budding out. Plants affected with brown or black root-rot show a decided tendency to wilt, particularly during mid-day, due to the reduced root systems.

Fig. 7.—Brown root-rot on tobacco. Varietal Resistance. Left, Judy's Pride; centre, Halley's Special, and right, Kelley.

Cause

The cause of brown root-rot in Ontario is due primarily to the nematode *Anguillulina pratensis*. The incidence of the disease has proved to be closely correlated with the preceding crop. In southwestern Ontario, it has been noted that brown root-rot is particularly severe in fields where tobacco has followed corn or soybeans in the rotation. The disease also frequently occurs where sod land has been planted to tobacco for the first time. Though brown root-rot may persist in the soil year after year, it is not usually severe after two or more consecutive tobacco crops. Other crops such as tomatoes and potatoes are also sometimes affected with brown root-rot.

Conditions which Favour the Disease

Investigations in Ontario have shown that the light-coloured, sandy and sandy loam soils are most favourable for the development of brown root-rot. In fields where the disease develops, higher areas are often more severely affected than lower ones. Low temperatures also favour brown root-rot. However, in Ontario the factor most consistently influencing its severity has been found to be the preceding crop. Careful investigations have shown that where one or more crops of corn have immediately preceded tobacco in the rotation, brown root-rot has been consistently severe. A similar but considerably less exaggerated condition sometimes occurs after other crops. The arrangement and number of offending crops preceding tobacco in the rotation also influence the severity of the disease. For example, successive crops of corn or soybeans, or corn alternating with soybeans, preceding tobacco, have consistently resulted in more severe brown root-rot than after a single crop of either corn or soybeans.

Control

It is unsafe practice from the standpoint of brown root-rot, particularly on the lighter soils of Essex and Kent counties, to precede tobacco in the rotation with corn or soybeans unless resistant varieties are used. Provided black root-rot is not present it is safer to follow tobacco with tobacco on soil where brown root-rot has developed in the past since brown root-rot is usually not severe on the second crop of tobacco.

Varietal susceptibility tests have indicated that of the Ontario-grown burley varieties Green Briar, Kelley and Judy's Pride are much more resistant than Harrow Velvet, Haronova, Halley's Special, Gay's Yellow and other varieties (Fig. 7). Of the flue-cured varieties White Mammoth, Bonanza, White Stem, Orinoco and Duquesne appear to be more resistant than the varieties Yellow Mammoth, White Stem Willow Leaf, Jamaica Wrapper, etc.

Black Root-rot

In the older tobacco-growing districts of Canada, black root-rot is often a serious disease, especially during cool, wet seasons. This disease may be severe either in the seed-bed or in the field, but losses result chiefly from infection of plants in the field. Up to the present time, black root-rot has been most serious in Essex and Kent counties of Ontario and the tobacco-growing districts of Quebec.

Symptoms

As the name indicates, the disease is characterized by a rotting of the roots which results in a starvation of affected plants. The disease can usually be identified by an examination of the root system, which is reduced in size, and is characteristically black in colour, either wholly or in part, depending on the severity of infection. The root system of infected seedlings is often completely decayed (Fig. 8). Above-ground symptoms consist of wilting and stunting, frequently accompanied by yellowing of the leaves, especially on

younger plants, and often by a premature budding-out (Figs. 9, 10). Both seed-beds and fields which are infested with black root-rot have a decidedly patchy appearance, some plants showing much greater growth than others.

Cause

Black root-rot is caused by the fungus *Thielaviopsis basicola*. This parasite is able to attack certain other plants, including beans, soybeans, and red clover, as well as tobacco, and is capable of overwintering and living year after year in the soil, in the absence of tobacco.

Conditions which Favour the Disease

Too much moisture, low soil temperature and alkaline soils favour the development of black root-rot. On the other hand, drought, high soil temperature or acid soil may prevent the disease from becoming serious, and often account for the late recovery of plants affected with black root-rot. Prolonged wet weather following transplanting usually results in more severe damage from black root-rot than abundant moisture later on, probably because of the lower temperatures prevailing at transplanting time. The application of lime to soils infested with black root-rot is almost certain to result in severe damage from the disease even though other factors may not be entirely favourable for its development.

FIG. 8.—Black root-rot on tobacco. Note rotted and blackened roots with a few healthy laterals on upper part of root.

FIG. 9.—Black root-rot in the field.
(Courtesy of Dominion Experimental Station, L'Assomption, Quebec.)

Control

The practice of avoiding the transplanting to the field of plants with black areas on their roots is doubly important, (*a*) because infected plants will either die or grow very slowly during the early part of the season, and (*b*) because infected seedlings will either inoculate field soil hitherto free from this serious disease or encourage an accumulation of the casual fungus in soil possibly only mildly infested up to that time.

Prevention of black root-rot in the field is obtained chiefly in two ways, (1) by a crop rotation of three years or longer, and (2) by the use of resistant varieties. In Canada it is not safe to plant varieties of tobacco susceptible to black root-rot in infested soil oftener than once in every three years on the lighter soils, and for a longer period on the heavier soils. Concerning the rotation of other crops with tobacco, it must be kept in mind that beans, soybeans and red clover also become infected with black root-rot. On the other hand, small grains, most truck crops, and corn remain free from the disease.

A knowledge of the soil alkalinity or reaction is also highly important when a grower intends to plant tobacco in a particular field. A soil reaction test by the nearest Experimental Station will determine for him whether it may be safe or unsafe from this standpoint to plant a susceptible variety on his land.

Care should be taken to keep fields free from infestation by this fungus and since the disease can be carried on field machinery and equipment, tools should not be transferred from contaminated to non-contaminated fields without first washing them, preferably with a disinfectant such as formalin.

The use of resistant varieties is highly important in the control of black root-rot. Though the more resistant varieties may not, at present, possess all of the desirable commercial characteristics, nevertheless, in a choice of varieties serious consideration should be given to them by growers. Considerable knowledge is at present available regarding the differences in susceptibility of the varieties more commonly grown in Canada, and lists of the varieties of each type of tobacco are given below, their relative resistance being approximately in the order they appear, the more resistant ones being named first and the most susceptible ones last.

FIG. 10.—Black root-rot showing relative resistance of Havana 142, a cigar binder variety grown in Quebec. No. 10 Connecticut Havana 38 and No. 11 Resistant Havana 142.
(Courtesy of Dominion Experimental Station, L'Assomption, Quebec.)

*Flue-cured varieties: Delerest, Gold Dollar 82C, Yellow Mammoth, Duquesne, Bonanza, White Stem Orinoco, White Mammoth.

Burley varieties: Harrow Velvet, Haronova, Harmony, Kentucky No. 16. Halley's Special, Type No. 5, Gay's Yellow, Kelley, Judy's Pride.

Cigar binder type: Resistant Havana, Havana 211, Havana 236, Connecticut Broadleaf (Williams), Comstock Spanish Pomeroy, Connecticut Havana No. 38 (Fig. 10).

Pipe varieties: Grand Rouge, Belge, Rose Canelle, Parfum d'Italie, Obourg de Vincent, Petite Havana, and Canelle.

Fusarium Wilt

In recent years the Fusarium wilt disease of tobacco has been responsible for some damage in certain areas of both the Old and New Tobacco Belts of Ontario.

Symptoms

The disease has been observed in the field in Ontario only late in the season. Symptoms consist of a wilting and yellowing of the plants. In only a few instances have affected plants died. More frequently, several leaves on one side of nearly mature plants collapse and die, while the other portions of the plants remain apparently normal. On these portions, certain leaves or parts of leaves may become yellowed or not fully developed, or they may die. If affected leaves are removed from the plants and the midribs sectioned, discoloration of the vascular system will always be found. Sections of the main stems of affected plants may or may not show browning of the vascular tissue.

Cause

This disease is caused by a soil-inhabiting fungus, *Fusarium oxysporum* Wr. var. *nicotianae*.

* Of the flue-cured varieties presently available Delcrest is the only moderately-resistant one. On the other hand, the burley varieties Harrow Velvet, Haronova and Harmony are all moderately or highly-resistant.

Conditions which Favour the Disease

In Ontario it has been observed that hot, dry seasons encourage this disease.

Control

Continuous cropping of tobacco should not be practised on fields or areas where this disease has occurred.

Broom Rape

In Kent county tobacco has been occasionally attacked in the field by broom rape, a parasitic flowering plant, but damage from this trouble has, so far, been slight.

Where it has occurred in Ontario, it could be identified by the short, yellowish plants with scale-like leaves appearing alongside and adjacent to the tobacco plants several weeks after transplanting to the field. Upon removal of the soil from the base of the tobacco plant the broom rape plants are found to be attached to the larger roots of the tobacco plant.

Cause

This disorder is caused by various species of broom-rape.

Control

Rotation with other crops should eradicate this parasitic plant, but so far it has not become necessary to employ such measures.

Mosaic

Mosaic is the most contagious disease affecting tobacco, and accordingly if certain precautions are not taken it may become widespread and seriously affect the yield and quality of leaf.

In Canada there are two different mosaic diseases, one caused by the tobacco mosaic virus, and the other by the cucumber mosaic virus. Moreover, there are several strains of each of these viruses present in most tobacco-growing areas, so that actually there may be several mosaic diseases, but in so far as the grower is concerned they may be considered as one disease, and are so treated in this bulletin.

FIG. 11.—Mosaic tobacco plant.

FIG. 12.—Leaf from mosaic plant showing mottling.

Symptoms

Symptoms of mosaic range from a fine, indistinct mottling, with little or no distortion of leaves or stunting, to a very pronounced mottling of alternate dark green and lighter green areas accompanied by severe distortion of leaves and stunting of the plant as a whole (Figs. 11, 12). The most pronounced symptoms are generally to be found at the top, on the more recently formed leaves, and on sucker growth after topping. Under certain conditions the lower leaves of mosaic plants develop numerous dead spots, the so-called "rust" stage of mosaic.

Control

Certain facts in relation to the various ways by which mosaic may be spread, should be clearly understood before discussing practical control measures. These facts are as follows: (1) the mosaic virus can exist on infected crop refuse in the soil from one season to the next (2) mosaic may be spread by handling or touching mosaic plants and then healthy ones. It is also spread by brushing against plants with clothing, cultivators, etc. This is especially true when the

plants are wet with dew or rain. (3) Mosaic can be transmitted by the hands of workers who smoke, or chew tobacco whilst working amongst tobacco plants, particularly if the workers use natural leaf and "roll their own." (4) Mosaic may be spread from boards or canvas if used a second time for seed-bed purposes; (5) mosaic may be carried by insects from mosaic plants to healthy ones or from infected solanaceous weeds, such as black nightshade, ground cherry, Jimson weed, etc. to tobacco.

With these facts in mind, it becomes apparent why the following recommended control measures are essential for the prevention and control of mosaic.

The seed-bed

1. The seed-bed should be located some distance from the curing barn or warehouse and the soil in the seed-bed should be sterilized.

2. If used boards or canvas are to be used again for a seed-bed, they should be thoroughly cleaned and sterilized, preferably by steam.

3. Weeds should not be tolerated in or near the seed-bed. Never weed or rogue the seed-bed while the plants are wet.

4. The use of tobacco by workers while working in the seed-beds should be prohibited.

5. The hands should be thoroughly soaped and washed under running water, before working in the seed-bed.

6. If mosaic appears in the seed-bed, the affected plants and the surrounding healthy plants should be removed and destroyed.

In the field

1. Tobacco should not follow tobacco in the rotation, some other crop such as rye, cereals, potatoes, etc. should intervene.

2. Tobacco should not be cultivated when wet with dew or rain.

3. Experience has shown that tobacco plants are very subject to mosaic infection during transplanting. Therefore here again the hands of the workman should be thoroughly and repeatedly washed.

4. From the standpoint of mosaic it is preferable to transplant under comparatively dry conditions rather than when plants and soil are unduly wet.

5. Tobacco should not be cultivated when the plants are wet, since mosaic is spread more rapidly under such conditions.

6. When the initial percentage of mosaic in the field is very low, it is advisable to rogue all diseased plants. This should be done before each cultivation, in order to avoid spreading mosaic during cultivation.

7. As the cultivator is a means of spreading mosaic, it is recommended that the cultivator be cleaned and washed before taking it into a tobacco plantation.

8. Since mosaic may be spread readily during suckering and topping, all healthy plants should be treated first, leaving mosaic plants till later. Before initiating operations the hands should be thoroughly washed and repeated washings during operations is advisable.

Ringspot

This virus disease is of little importance in Ontario or Quebec, though it is found each year, particularly in the Old Tobacco Belt in Ontario.

Symptoms

The outstanding symptom appears on the leaves as yellow rings or concentric line patterns (Fig. 13), which later break down, giving rise to rings of

FIG. 13.—Ring spot on tobacco leaf.

dead tissue. Affected plants are often stunted in growth. As with mosaic, ringspot has a wide range of weed hosts, but unlike mosaic, it may be carried in the seed from affected plants.

Control

1. Use seed from healthy plants.
2. Do not permit weeds in seed-bed or field.
3. Rogue and destroy diseased plants early in the season.

Streak

This disease was first observed in Ontario in 1937. It was encountered again in 1938 when it caused appreciable loss in a few fields in Kent county. Since then streak has been found in both Ontario and Quebec in most seasons, though the number of affected plants has been small and the disease is apparently of minor importance.

One interesting feature of this disease is that it is generally concentrated along a border or borders of a field, thus suggesting that the disease had been transmitted to tobacco by insects from some nearby crop plant or weed. On several occasions streak has appeared in tobacco when planted near sweet clover fields and research at the St. Catharines Laboratory of Plant Pathology has indicated that this crop may be a host of the streak virus thus establishing the fact that streak may be spread from sweet clover to tobacco. Whether or not other field crops or weeds may play a similar role has yet to be ascertained.

Symptoms

The most common symptom consists of dead areas of leaf tissue, in the form of fine dots, rings, and streaks, which may involve the greater part of the leaf blade (Fig. 14). Conspicuous brown necrotic (dead) areas may also be present on the stalk and leaf petioles. Not all leaves of an affected plant necessarily show necrosis, in fact, generally only a few centre leaves are thus affected. The leaves above the necrotic section may or may not show an indistinct mottle, but are invariably narrower than normal. On some varieties, especially Kelley and White Burley, the tip of the plant often becomes twisted or crooked.

Cause

Investigations have shown that streak in Ontario and Quebec is caused by a virus. Streak, then, like tobacco mosaic is a virus disease, but streak is not so contagious as tobacco mosaic and little, if any, spread results from contact, cultivation, etc. Though mosaic overwinters in the soil, so far as is known, streak does not. While mosaic may be spread from other solanaceous crop plants or weeds to tobacco by means of insects, so far as is known sweet clover is the main source from which streak may be spread to tobacco. However, it is possible that other field crops or even weeds may act as a reservoir of the streak virus.

FIG. 14.—Tobacco streak. Note the fine necrotic spotting and distortion of leaves. Also note that top of plant is twisted.

Control

Avoid planting tobacco in close proximity to fields of clover. Weeds should not be tolerated in the tobacco field, in fence rows, etc.

Angular Leafspot

Angular leafspot is a bacterial disease which occurs to some extent every year, and during wet seasons it is frequently prevalent and occasionally destructive throughout the tobacco-growing districts of both Ontario and Quebec. Due probably to the higher summer rainfall in Quebec, the disease is usually more severe in the Quebec than in the Ontario tobacco-growing districts.

Symptoms

This disease may appear on plants at any stage of development from seedling to maturity. On seedlings the first signs of the disease usually are several angular, dark-coloured spots on a single leaf. These spots are generally much smaller than those on mature plants and have a narrow, translucent margin.

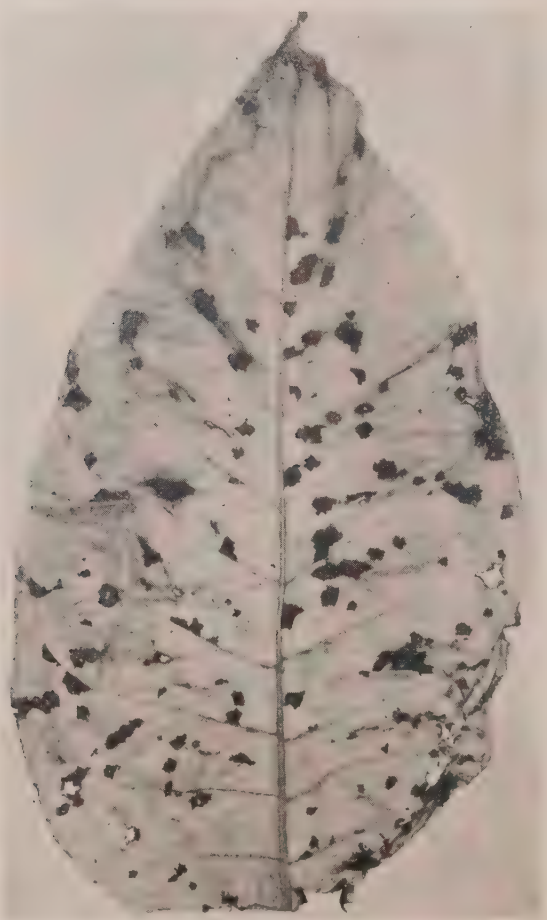

Fig. 15.—Angular leaf spot on tobacco.

Fig. 16.—Angular leaf spot showing large zonate type of spots.

On plants in the field the spots are characteristically angular and vary in size (Fig. 15). Spots on dark tobacco are usually large and zonate (Fig. 16). Following severe rainstorms the ordinarily small leafspot caused by the bacteria may involve large areas and sometimes entire leaves, due to the water-soaking of tissues around the spots, and their subsequent invasion by the bacteria. Frequently in such cases, little leaf tissue remains attached to the stalk.

Cause

Angular leafspot is caused by a bacterium named *Phytomonas angulata*. This parasite is capable of invading tobacco leaves, especially through injuries. Under conditions of excessive moisture within and on the leaf, the bacteria multiply rapidly and then serve as sources of further infection on the same or other leaves. Some of the bacteria overwinter successfully, probably on tobacco trash, seed, seed-bed cloth, and by other means, and these serve to renew the disease each spring, unless treated as shown below under "Control".

Conditions which Favour the Disease

Wind and rainfall play major roles in the dissemination of the bacteria causing angular leafspot, both in the field and in unprotected seed-beds. This is due to the fact that the splashing of the rain, as a result of wind, spreads bacteria from leaf to leaf and from plant to plant, and causes large portions of the tissue to become watersoaked, thus enabling the bacteria easy access to healthy tissues. High temperatures also favour the disease.

Control

Control measures for this disease largely centre around the problem of obtaining healthy seedlings. Seed pods showing no sign of infection should

always be selected for seed. The selection of seed should be supplemented by disinfection with silver nitrate according to instructions already given under "Seed selection and treatment". Where angular leafspot has been severe, the seed-beds should either be steamed, or if possible be established on new ground, well removed from fields in which tobacco has recently been grown. Old tobacco refuse should not be used on seed-beds. When cloth is used, it should either be renewed each year or sterilized in boiling water. It should also be kept in mind that this disease may be spread by the hand or clothing of workers during the various operations; also that the disease spreads more readily from infected plants that are wet than from those that are relatively dry. The rotation of other crops with tobacco and the early ploughing-under of stubble are also good preventative measures.

Wildfire

Wildfire is a leafspot disease which resembles angular leafspot very closely in most respects. In Canada this disease has been sporadic in its appearance. It has appeared most frequently in the Yamaska valley in Quebec, and has been observed occasionally in the tobacco district north of Montreal and at Ottawa. It may also occur occasionally in the Ontario tobacco-growing districts, and a careful watch should be kept at all times for its occurrence.

Fig. 17.—Wildfire on tobacco. Note halo surrounding dead central area.

Symptoms

Although wildfire is primarily a leafspot disease it also occurs upon the flowers and seed pods. It may appear on the leaves at any time from the seedling to the mature plant stage. A wet-rot phase often appears earliest and involves the leaf margins and tips of affected plants with a watersoaked zone between the living and the dead tissue. This phase is followed at about transplanting time by one in which tiny, circular, yellowish-green spots appear on other leaves. In a short time a small, brown area appears in the centre of each spot, and the wide, yellowish-green margin or halo becomes more prominent (Fig. 17). The spots increase in size and prominence, often reaching a diameter of $\frac{1}{2}$ inch or more. In addition to this type of lesion which develops under ordinary conditions, a much larger and more destructive type of spot develops after severe storms. In such cases large areas of leaves and sometimes whole leaves become infected and die, with little or no halo effect at the margins.

Cause

Wildfire is caused by the bacterium called *Phytomonas tabacum*. This parasite resembles very closely the one causing angular leafspot in both appearance and behaviour. It overwinters apparently by the same means as angular leafspot.

Conditions which Favour the Disease

The conditions that favour angular leafspot also favour wildfire.

Fig. 18.—Two types of non-parasitic leaf spots.

Control

The control measures outlined for angular leafspot apply equally well to wildfire.

Non-parasitic Leafspot

This small brown leafspot, which later may or may not turn white, has been encountered annually on flue-cured and burley varieties, though observations to date would suggest that it is more general and severe on flue-cured varieties.

Symptoms

The disease first manifests itself as small brown spots, which later become dead and often turn white (Fig. 18). With burley varieties especially, an indistinct halo sometimes surrounds the dead tissue. The degree of spotting may vary from a few widely-separated ones to a condition in which the leaf is entirely covered with spots. Severely-affected leaves do not mature normally and as a result are lowered in grade.

Cause

The cause of this disease is as yet undetermined. It may be the result of an improper potassium-nitrogen balance in which high phosphate content of the soil has a tendency to alleviate the trouble.

Control

At the present time no control measures can be recommended beyond suggesting that analysis of the soil be made and fertilizer recommendations be followed.

Frenching

Frenching may be found in the seed-bed (Fig. 19) or in the field (Fig. 20). Several cases of frenching have been observed in seed-beds in both Quebec and Ontario. Under seed-bed conditions frenching is sometimes confused with mostic, although it is a distinct disease and of rather frequent occurrence.

Symptoms

The earliest symptom is a chlorosis of the margins of young leaves which later spreads toward the mid-rib until ultimately the whole leaf becomes yellow, with the network of veins green. Severely-affected plants are stunted and the leaves often become elongated, narrow, and severely distorted. The tips of the leaves often curl downward, while the margins become wavy or undulated. Under certain conditions affected plants produce an unusually large number of small, strap-like leaves. Sometimes it is found on suckers only, the rest of the plant appearing to be normal. Both in Ontario and Quebec some of the most severe cases of frenching have been observed on light soils that have grown tobacco for the first time.

Cause

The cause of frenching is unknown, though intensive investigations of the disease have been conducted at various times. There is some reason to believe that lack of aeration, excessive moisture in poorly-drained soils, and an unfavourable soil reaction are contributing factors in Ontario. Experimental evidence and field observations indicate that frenching is greatly favoured by an alkaline soil.

FIG. 19.—Frenched tobacco seedlings.

FIG. 20.—Severe frenching in the field. 1. Severe frenching; note strap-like leaves. 2. Row of severely-frenched plants between two rows of mildly-frenched plants.

Control

Frenching does not appear to be so prevalent on well-drained and fertilized soils that have an acid reaction. Also, tobacco should not be grown on soil that has repeatedly grown crops of severely-frenched tobacco.

Hollow Stalk

Though this disease is as yet of no great importance, it has been found both in Ontario and Quebec. It is favoured by wet seasons.

Symptoms

Black, diseased areas on the stalk in the form of either stripes or complete girdling, and hollow stalks caused by the destruction of the pith are diagnostic of this disease. The bacteria which cause hollow-stalk enter through wounds, and it has been observed both in Ontario and Quebec that infection apparently takes place through the wounds resulting from topping.

Cause

This is a bacterial disease, probably caused by *Erwinia carotovora* or *Erwinia aroideae.*

Control

This disease is as yet of such minor importance that preventive measures are unnecessary.

Root Knot

Under conditions of high soil temperature, root knot may be a serious disease of tobacco in light soils. Though the disease has been comparatively unimportant in Canada to date, it has been found in Ontario attacking both tobacco seedlings and plants in the field.

Symptoms

This disease is characterized by knot-like enlargements varying in size from scarcely-visible swellings on the smaller rootlets, to elongated swellings an inch or more in diameter on the larger roots. Affected seedlings become stunted and yellow and usually occur in patches in the seed-bed. In the field infected plants are stunted and wilt readily in dry, hot weather, and may eventually be killed.

Cause

Root knot is caused by the nematode or eel-worm called *Heterodera marioni.*

Conditions which Favour the Disease

Light, sandy soils favour the development of the disease much more than do the heavier soils. Plants grown in fields where the nutrient level is low are more severely affected than where an abundance of mineral nutrients is present. High soil temperatures are especially favourable for this nematode and the latter become inactive as soon as temperatures drop to 50° F. or lower.

Control

In the control of root knot it is essential, in the first place, to prevent infection of seedlings in the seed-bed. Sterilization of the soil by steam or chemical will destroy the nematodes if present, and they are not apt to be present in the seed-beds if the latter are located on land which has not recently been cultivated. When fields become infested it is possible to control root knot only by practising a system of rotation in which non-susceptible

crops are grown for a period of years. Usually three years are sufficient to keep down weeds on which the nematodes feed. Such crops as corn, wheat and rye can be grown safely during this period. The application of nitrate of soda has also been shown to somewhat counteract loss due to these nematodes.

Albinism

Occasionally patches, of irregular outline and size, and varying in colour from almost pure white to yellow are observed on certain plants in the field. Such patches are usually outlined by the veins and the colour of the upper and lower surfaces of affected areas in the leaf may be either the same or different. The symptoms in general impart a marbled appearance to affected plants.

This condition on tobacco plants resembles variegation in horticultural plants such as geranium, for instance, where such an abnormality is valued. There is no evidence that it is infectious and it appears to be hereditary to some extent.

Lightning Injury

Lightning injury is occasionally observed, and when present is found in more or less circular areas, with the plants in the centre most severely affected, and often killed, whereas the plants towards the margin of the area are less severely affected, and show various symptoms. In the latter instance, the leaves on one side may be wilted or dead, while those on the other may be normal. A brown to black streak or band may extend along one side of the stalk and out into the petioles and mid-ribs of the leaves, causing a puckering of affected leaves with wilting. Later the growth of normal tissue of affected plants often causes the stem to turn downward or twist, and the leaf tissue becomes puckered (Fig. 21).

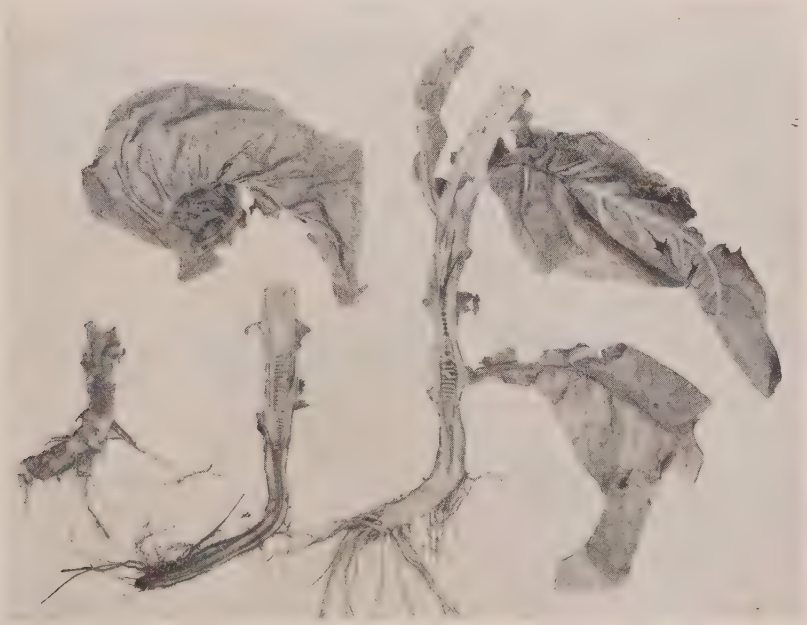

Fig. 21.—Lightning injury.

Fig. 22.—Hail injury.

Hail Injury

In 1937 hail caused considerable damage both in Ontario and Quebec, though its distribution was quite limited in area. If hail strikes small plants, they may outgrow the damage to a considerable extent. Plants with larger leaves obviously are more seriously damaged and the crop may be a total loss, with the leaf blade shredded and even the plants uprooted. Grey, sunken areas mark the places where the hail stones strike the stalks and petioles (Fig. 22).

SYMPTOMS ON TOBACCO ASSOCIATED WITH A DEFICIENT SUPPLY OF CERTAIN CHEMICAL ELEMENTS

Potash Deficiency

Where potash is deficient, characteristic symptoms develop. The lower leaves of affected plants exhibit a mottling or chlorosis towards their tips and margins, which is soon followed by a breakdown in the form of dead spots in the leaf tissue. This dead tissue may involve the tip only, or the entire leaf. The margins and tips of affected leaves often curl downwards and inwards (Fig. 23). As the condition progresses, affected leaves take on a ragged, rusty appearance, often with a noticeable puckering of the tissues between the veins. The mottling or chlorosis of the leaves usually progresses upwards on the

FIG. 23.—Potash deficiency on tobacco. Note chlorosis at edge and tip of leaf.

plant, but the bud leaves always retain their normal colour. Dry weather tends to exaggerate these symptoms. Cured leaves from a crop suffering from potash starvation are thin and dull in appearance, and lack elasticity, aroma, and satisfactory burning quality.

Nitrogen Deficiency

Nitrogen deficiency occurs every year to some extent in certain fields of flue-cured and burley tobacco in Ontario. This is accounted for by the fact that although a continuous supply of nitrogen is required by all types of tobacco for normal growth and suitable leaf quality, nevertheless, for flue-cured and burley type a relatively low level should be maintained during the growing period with a reduced level as the plant approaches maturity in order to obtain both yield and quality. Thus, if best practice is followed in production of the above-mentioned types of leaf the margin of safety between an adequate supply and definite deficiency under certain weather conditions is not great. Consequently, excessive rainfall during the early part of the growing season, especially on the light soils where flue-cured tobacco is grown in Ontario, not infrequently results in prevalent signs of nitrogen deficiency. On the other hand a deficiency of nitrogen rarely occurs in Canada on cigar leaf or other dark tobacco types because the objective in these cases demands the maintenance of a continuous high level of nitrogen throughout the growing season in most cases on relatively heavy soils.

Phosphorus Deficiency

When phosphorus is not supplied to tobacco plants in sufficient quantity, they assume an abnormally dark green colour and a rosetted condition. Growth is delayed and the leaves are narrower than normal. Small, dark brown, dead areas have also been observed in some seasons on plants supplied with insufficient phosphorus. Leaves from phosphorus-deficient plants remain immature and hence are an unsatisfactory colour when cured, tending to be brown or black.

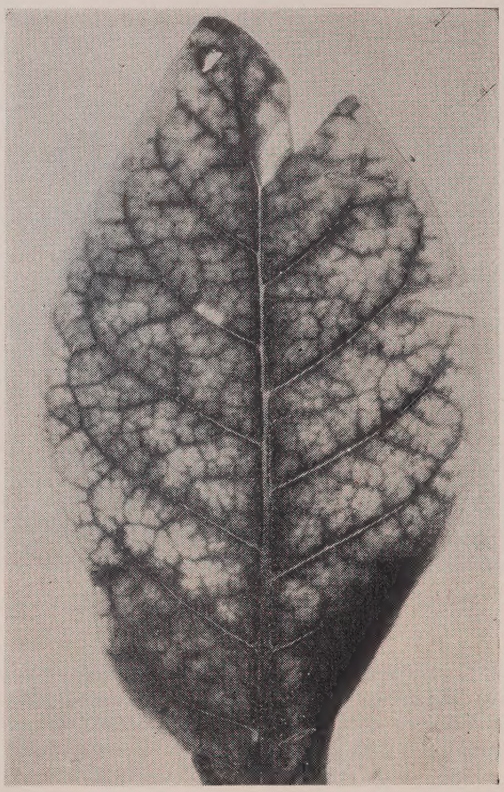

FIG. 24.—Magnesium deficiency on tobacco. Note chlorosis of areas between the veins.

Magnesium Deficiency (Sand Drown)

Though a deficiency of magnesium is not often apparent in Canadian tobacco soils, it has been observed occasionally during wet seasons in both the Old and New Tobacco Belts of Ontario in flue-cured tobacco. This condition has long been referred to as "sand drown" in the United States.

Symptoms of magnesium deficiency do not appear until rather late in the growing season but are characteristically striking because of extreme chlorosis. This yellowing begins at the tips and margins of the bottom leaves and continues until in severe cases entire leaves and most of the plant is involved. It is characteristic for the veins and a certain amount of adjacent tissue of affected leaves to retain their normal colour (Fig. 24). Affected leaves assume a dull, pale yellow colour, and after curing, lack good colour, are thin, lifeless, and break easily at the tips. If indications of potash, nitrogen, phosphorus, or magnesium deficiencies are noted, soil samples should be taken to the nearest Experimental Station for chemical analysis and advice as to corrective measures.